AIR QUALITY

NORTHWESTERN ONTARIO

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SUMMARY

This report presents results of the Ministry's air quality assessment program in northwestern Ontario for 1982. It includes data from nine communities where long-term monitoring is conducted, plus summaries of special studies in the Thunder Bay area.

ATIKOKAN

Pre-operational sampling was carried out near Ontario Hydro's power plant under construction at Atikokan. As expected, this survey showed residual arsenic and iron contamination in vegetation and soil around iron ore mines which were formerly active in the area.

Suspended particulate matter, monitored at the Atikokan Weather Station, continued to be recorded at satisfactory levels.

BALMERTOWN

Arsenic persisted at elevated concentrations in vegetation on company property near two gold mines, but was at, or near normal, in the adjoining townsite. Arsenic and mercury met guidelines in all vegetable samples from residential gardens.

There were 104 sulphur dioxide readings above the maximum acceptable limit in 1982. Vegetation damage caused by this pollutant occurred in a 33-hectare area, mostly on company property. To decrease or eliminate vegetation injury in the townsite, Campbell Red Lake Mines Limited is implementing a program to reduce sulphur dioxide emissions.

DRYDEN

As a result of earlier abatement action at the kraft pulp mill in Dryden, dustfall continued to substantially comply with Ontario regulations.

Odour levels declined sharply in 1982, partly because of reduced production at the pulp mill, but also because of decreased mill emissions resulting from pollution abatement.

FORT FRANCES

The zone of vegetation injury near the Fort Frances kraft pulp mill was the smallest recorded since the mill was constructed. Visible vegetation damage was, for the first time, totally confined to a buffer zone around the mill. Visible injury was also absent in vegetation off company property near the mill's secondary treatment system.

While dustfall and suspended particulate matter both declined in 1982, emissions of wood fines from mill property were sometimes higher than desirable.

Odour levels improved significantly in 1982, but were still far short of satisfactory. Further odour controls at the mill, scheduled by September, 1983, are expected to further decrease the frequency of high odour readings.

KENORA

A brief upset condition in the Boise Cascade sulphite pulp mill resulted in sulphur dioxide damage to vegetation in a small area nearby. The company took steps to prevent a recurrence.

Below-normal production levels at the mill, plus improved control of power boiler emissions, resulted in generally acceptable dustfall levels in Kenora in 1982.

MARATHON

Average airborne sulphur levels showed little change from 1981 to 1982. To determine whether current levels are acceptable, a continuous monitor was installed late in the year.

There was little mercury in surface water draining soil in the area around the kraft pulp mill at Marathon.

RED ROCK

Dustfall and odours continued to be periodically recorded at high levels at some sites in Red Rock. Levels of both these

contaminants should fall sharply in 1983 as a result of reduced emissions from a new recovery furnace installed in late 1982 at the local kraft pulp mill.

TERRACE BAY

Very few readings of reduced sulphur were recorded above the provincial guideline. Kimberly-Clark, the operator of a kraft pulp mill in Terrace Bay, has installed equipment to telemeter data to the mill from a Ministry monitor in the townsite. This action should provide prompt warning of any malfunctions at the mill which could cause elevated odour levels in the community.

THUNDER BAY

Average dustfall in Thunder Bay was well within the acceptable range in 1982, and was essentially unchanged from the 3 preceding years. Periodically high readings at two sites in the Westfort area resulted from flyash emissions from Great Lakes Forest Products Limited. These emissions should decrease sharply before the end of 1983 when the company completes the installation of dust control equipment.

Suspended particulate matter in the air was satisfactory during the year, with 97 percent of the samples meeting the Ontario air quality objective. The reduction of dust levels in Thunder Bay is attributed mostly to major dust abatement programs at the grain elevators in the city.

Full compliance was achieved for all air quality objectives for sulphur dioxide at the nine sites where this pollutant is measured. Total reduced sulphur (TRS) levels near Great Lakes Forest Products Limited also improved during the year. The TRS guideline was exceeded only 7 times in 1982, compared with 72 times in 1981. Periodic production shutdowns at the Great Lakes kraft mill in 1982 may have contributed to the better air quality.

Ozone, a pollutant usually associated with long-range transport, met the Ontario air quality objective at all times.

INTRODUCTION

PURPOSE OF MONITORING PROGRAM

The Ontario Ministry of the Environment conducts an air quality assessment program throughout the province. This program measures the levels of pollutants in outdoor air that may adversely affect human health, animal life, vegetation, and the use and enjoyment of property. These surveys also record compliance with air quality objectives, evaluate the need and effectiveness of pollution controls, and determine long-term trends in air quality.

In northwestern Ontario, air quality surveys first began in 1963 to measure airborne dust at one site in the City of Thunder Bay. By 1982, the program included eight pollutants, monitored by more than 90 instruments in nine urban centres. Ontario Hydro also operates air quality networks in Thunder Bay and Atikokan. Data from air quality instruments are supplemented by vegetation, soil and snow sampling studies, and by predictions of pollutant levels with mathematical models.

Monitoring in the region is concentrated in urban areas and near industrial sources of air pollution (eg. mining, pulp and paper). Therefore, air quality problems described in this report are not typical of the region as a whole, where air quality is generally excellent.

In recent years, acid rain has become a major environmental issue in eastern North America and parts of Europe. Ontario, through its Acidic Precipitation in Ontario Study (APIOS) has mounted a long-term program to assess the effects of acid deposition and to develop possible answers to this problem. The Ministry's Northwestern Region participates in this program through precipitation sampling surveys and research on the aquatic and terrestrial effects of acid rain. The findings of these studies will be reported elsewhere.

One of the future goals of the air quality program in northwestern Ontario is to install a telemetry system to improve the

quality of data and the speed with which it is received. A telemetry system will permit us to obtain immediate readings from any continuous monitor in the region.

POLLUTANTS AND THEIR MEASUREMENT

In this section, only those contaminants routinely monitored in northwestern Ontario will be considered. Carbon monoxide, nitrogen oxides and hydrocarbons are not presently measured, nor are exotic organic compounds. If the need arises, many of the more unusual pollutants can be monitored with mobile equipment from the Ministry's Air Resources Branch, Toronto.

Particulate Matter

There are many man-made and natural sources of particulate matter. Typical man-made sources in northwestern Ontario are grain elevators, forest product industries and mining operations. Wind-blown particles from stored materials and roadways are examples of secondary sources. Particulate matter may also be emitted from forest fires, volcanos, and dust storms. Depending on particle size and chemical makeup, particulate matter may be injurious to health and vegetation, may adversely affect visibility, and may cause local nuisance problems. In northwestern Ontario, particulate matter is measured as dustfall, total suspended particulate matter (TSP), or soiling index.

Dustfall represents fallout of particulate matter that settles out from the air by gravity. Open-top containers (dustfall jars) are exposed for 30-day periods and the collected matter is weighed. The monthly air quality objective (maximum acceptable limit) for dustfall is 7 $g/m^2/30$ days (grams per square metre for 30 days), and the objective for the annual average is 4.6 $g/m^2/30$ days. Dustfall provides an estimate of fallout of particulate matter from local sources, including dust from nearby construction or vehicle traffic on dusty roads.

Suspended particulate matter comprises particles of small size which remain entrained in the air for extended periods.

This matter may originate from local or distant sources. It is measured with a high-volume sampler for a 24-hour period every sixth day (1). The difference in the weight of a fibreglass filter before and after exposure determines the quantity of particulate matter collected. The air quality objective is 120 $\mu g/m^3$ (micrograms per cubic metre of air) averaged over 24 hours, or 60 $\mu g/m^3$, annual geometric mean.

Soiling index is a measure of the soiling or darkening properties of suspended particulate matter expressed as coefficient of haze (COH). It is probably closely related to the concentration of respirable particulate matter. A measured volume of air is drawn through a paper tape which is advanced through an automated sampling unit to produce a reading every two hours. The reduction of light transmitted through the tape is expressed as coefficient of haze (COH) per 1,000 linear feet of air sampled. The Ontario objective is 1.0 COH, 24-hour average, and 0.5 COH, annual average.

Gaseous Pollutants

Sulphur Dioxide

Gaseous pollutants currently monitored in northwestern Ontario include sulphur dioxide, total reduced sulphur, fluoride, and ozone. Sulphur dioxide (SO_2) is one of the world's major atmospheric pollutants and has many well-known adverse effects on human health, vegetation and property. It is also one of the main contributors to the formation of acid rain. In northwestern Ontario, the principal SO_2 sources, which are small compared to some other parts of the province, are the Ontario Hydro generating station in Thunder Bay, sulphite pulp mills, industrial boilers, and gold ore roasting. SO_2 may be measured with passive samplers (sulphation plates) to provide a semi-quantitative estimate of the presence of sulphur-containing gases. It can also be specifically monitored with continuous analyzers. There are three air quality objectives for this pollutant: 0.25 ppm (parts of sulphur dioxide per million parts of air, by volume), hourly average; 0.10 ppm, 24-hour average; and 0.02 ppm, annual average.

Total Reduced Sulphur

Total reduced sulphur (TRS) comprises a group of sulphur-containing gases found in emissions from kraft pulp mills, which are the sole significant TRS source in the region. At very low concentrations, TRS results in offensive odours. Higher levels may cause temporary respiratory irritation or may injure vegetation. In Ontario, a guideline of 27 ppb (parts of TRS, expressed as hydrogen sulphide, per billion parts of air, by volume), averaged over one hour, is used as an air quality objective near kraft pulp mills. TRS may be measured with sulphation plates, for semi-quantitative results, or with automated analyzers to record TRS continuously.

Ozone

Ozone occurs naturally and beneficially in the upper atmosphere. Near the ground, it is a secondary product of reactions between nitrogen oxides and hydrocarbons and, if elevated, may be detrimental to health and injurious to vegetation. Since ozone-forming compounds are not emitted in large amounts in northwestern Ontario, any elevated ozone readings implicate long-range transport from outside the region. Ozone is measured with continuous analyzers, and the current air quality objective is 0.08 ppm, averaged over one hour.

Fluoride

In northwestern Ontario, a brick and tile plant near Thunder Bay is the only known significant industrial source of airborne fluoride. Fluoride may injure vegetation or impair the health of livestock which has consumed fluoride-contaminated forage. Fluoride in air is monitored with passive samplers (lime candles) which estimate mean monthly fluoride levels. The fluoride formed by the reaction of hydrogen fluoride with lime-impregnated filter paper is expressed as μg F/100 cm^2/30 days. The maximum acceptable limit is 40 μg F/100 cm^2/30 days for the growing season (May to September), and 80 μg F/100 cm^2/30 days for the rest of the year.

Miscellaneous

The presence and effects of some of the foregoing pollutants, as well as others, are also assessed through vegetation injury and through contaminant levels in vegetation, soil and snow. Standard Ministry procedures (2, 3, 4) are followed in collecting and analysing these types of samples. Arsenic, chloride, fluoride (5), sulphur and heavy metals are typical contaminants examined with these techniques. Their levels in a study area are compared with normal background levels at sites not affected by pollution.

Dustfall, sulphation, and suspended particulate matter, as well as most analyses for vegetation, soil and snow, are determined at the Ministry's Thunder Bay laboratory. Metals, nitrate, and sulphate in suspended particulate matter, and sulphur and halides in vegetation and soil, are analysed at the Ministry's central laboratory in Toronto. The central laboratory also provides a service for the determination of unusual contaminants (e.g.: organic compounds such as PCB's or pesticides).

The Ministry's Air Resources Branch processes the strip charts from continuous analyzers, and produces computer printouts of all air quality data for the region. The Thunder Bay regional office is developing computer programs to improve access to air quality and meteorological data in Toronto.

RESULTS AND DISCUSSION

ATIKOKAN

Ontario Hydro Generating Station

In 1981, the Ministry and Ontario Hydro began a pre-operational air quality assessment program around a lignite-fired generating station under construction near Atikokan. Ontario Hydro operates the air quality monitoring network and the Ministry is responsible for precipitation sampling, vegetation and soil studies, and snow sampling (Figure 1). By 1984, when the 200-megawatt plant is completed, about 3 years of background data will have been collected.

Consultants for Ontario Hydro are submitting quarterly and annual air quality reports, and the Ministry is preparing annual reports on terrestrial studies. The Ministry report for 1981 confirmed the presence of residual arsenic and iron contamination in vegetation and soil near the power plant. The source of the arsenic and iron was historical emissions from nearby iron ore pelletizing plants which operated from the mid-1970's to about 1980 (6). The Ministry and Ontario Hydro plan to continue their monitoring programs for several years after the generating station is commissioned to ensure compliance with environmental regulations.

Particulate Matter

At its long-term monitoring site in the Town of Atikokan, TSP never exceeded the 24-hour air quality objective of 120 $\mu g/m^3$. The annual geometric mean of 20 $\mu g/m^3$ was well below the maximum acceptable limit of 60 $\mu g/m^3$, and was the lowest average recorded since monitoring started in 1966. The year-to-year variation in average TSP at Atikokan is attributed to long-range transport, climatic differences, or local construction activities.

BALMERTOWN

The Ministry has conducted air quality surveys near two gold mines in Balmertown since 1971. For many years, Campbell Red Lake Mines Limited, and the Dickenson-Sullivan Joint Venture, Arthur W. White Mine (formerly Dickenson Mines Limited), emitted significant amounts of airborne arsenic trioxide and sulphur dioxide from ore roaster stacks. In the mid-1970's, both mines reduced arsenic emissions by more than 95%. In early 1980, Dickenson changed its ore processing methods and shut down its roaster.

Arsenic

Air quality samples were obtained routinely by Campbell Red Lake Mines for several years after arsenic emission controls were

introduced at its mine in 1974. Arsenic in these samples, from the centre of the townsite, were consistently well below the maximum acceptable limit for airborne arsenic (7).

In 1982, arsenic concentrations in leaves of trembling aspen trees at 16 sites near the mines (Figure 2) were elevated on company property but were usually at, or near, normal levels in the townsite (Figure 3). Results from a 1982 snow sampling survey were similar. The high arsenic levels near Campbell's roaster are attributed to fugitive emissions during roaster start-up or shutdown, or to emissions when trucks are loaded with arsenic waste from the roaster baghouse. Table 1 compares arsenic readings for the past 11 years at selected sites on and off company property. Table 2 presents 10 years of data from planted roadside trees in the townsite. Arsenic levels in townsite trees are now about 98 percent lower than those recorded before emission controls were in place.

In garden vegetables, arsenic was again well below the limit (10 μg/g, dry weight) specified by the Health Protection Branch, Canada Department of Health and Welfare (Table 3). Because arsenic in garden soil remains high, residents are advised to thoroughly wash vegetables from Balmertown gardens before consumption.

Mercury

Because mercury is used in ore processing at the mines, the Ministry has carried out several surveys to examine mercury concentrations in local vegetation, soil and snow. The 1982 data show that while mercury was elevated in vegetation and snow close to the mines, it was about normal in the townsite. All samples of vegetables from residential gardens met the recommended international guideline for mercury. In late 1982, Campbell Red Lake discontinued the use of mercury in ore processing.

Sulphur Dioxide

Sulphur dioxide (SO_2) sometimes exceeds desirable levels in Balmertown. In 1982, the Ministry's Balmertown monitor recorded 104 hourly readings and eight, 24-hour averages which exceeded acceptable levels. The maximum hourly average was 0.73 ppm, about three times the Ontario objective. The annual average (0.013 ppm) was satisfactory. Periods of high SO_2 during the growing season caused injury to trees, shrubs and other plants in a 33-hectare area (Figure 4). Although the 1982 injury zone was larger than usual, most of the damage was on Campbell's property.

Of several SO_2 abatement options considered, Campbell Red Lake has proposed a Voluntary Emission Reduction Program. This program is now in place and is designed to reduce or eliminate SO_2 emissions during the growing season when winds blow from the mine to the townsite. A proposed Control Order, expected to be in force by the fall of 1983, requires the company to submit quarterly reports to the Minstry on roaster shutdowns due to this SO_2 abatement program. The Ministry expects that this action will reduce or eliminate vegetation damage in the townsite.

DRYDEN

For several years, the Ministry has monitored air quality near a bleached kraft pulp mill and adjacent chlor-alkali plant in Dryden. Our earliest surveys showed that mercury, particulate matter and offensive odours around the mill were often well above normal levels. Abatement action and process changes in the 1970's successfully controlled the discharge of mercury and particulate matter. In 1982, the Ministry continued to monitor dustfall and odours.

Dustfall

Total dustfall continued to be recorded at generally satisfactory levels at the six monitoring sites (Figure 5) in Dryden. At two sites, the annual average was a little above the Ontario

objective (Table 4). Since improved dust emission controls were put in place at the mill in 1977, dustfall levels in the town have been stable. There is no evidence that mill operations have any significant effect on dustfall currently measured in Dryden. Modernization of the kraft mill, to be completed in 1983, is not expected to affect local dustfall.

Odour Levels

Offensive odours in the community are monitored with sulphation plates and a continuous total reduced sulphur (TRS) analyzer. The data for 1982 (Tables 5 and 6) both clearly show improved air quality. The maximum TRS reading (139 ppb), the annual average TRS concentration (2.1 ppb), and the number of hours of TRS above the provincial guideline were all well below those in previous years. Some of this improvement was due to periodic mill shutdowns during the year. However, analysis of wind and air quality data when the mill was running shows that much of the decline in odour concentrations could be ascribed to reduced emissions from the mill. Further decreases in odour levels are expected in 1983, when the new mill should be operating normally.

FORT FRANCES

Emissions from a bleached kraft pulp mill in Fort Frances have resulted in excessive fallout of particulate matter, high concentrations of malodorous gases, vegetation damage, and complaints from nearby residents. Since 1971, when the mill was constructed, a "buffer zone" has been created through purchase of adjacent residential land. Some emission reductions were also achieved and, in 1980, a Control Order was issued to enforce compliance with Ministry regulations.

Air quality studies in Fort Frances have been conducted regularly since 1972 near the Canadian mill and since 1974 near a similar plant owned by the same company on the U. S. side of the border (Figure 6). In 1982, this monitoring program also included surveys around the Canadian mill's secondary treatment system.

Vegetation Effects

The zone of vegetation injury near the Fort Frances kraft mill was the smallest recorded since the mill started production. Damage was restricted to the company's buffer zone on the south side of Nelson Street (between Mowat and Portage), and along Portage Avenue (between Nelson and Sinclair). Because of past damage caused by mill emissions, there are now very few trees in the part of the buffer zone nearest the mill. Chloride and sodium in foliage of Manitoba maple from 17 sites (Figure 6) were elevated only in the buffer zone (Table 7). The pronounced decline in chloride and sodium in 1982 is attributed partly to improved pollution controls at the mill and partly to effects of insect damage to Manitoba maple. Cankerworms caused severe defoliation early in the growing season, and the original leaves on many sample trees had been replaced by a second set. The second growth would, therefore, have had shorter exposure to airborne contaminants than leaves in a normal growing season.

In contrast to 1981, no visible vegetation injury was found off company property around the aeration lagoons at the secondary treatment system (Figure 7). However, chloride and sodium were very high in leaves of trembling aspen trees at several points within 100 metres of the perimeter fence around the treatment system. A moss exposure experiment between August 10 and September 29 confirmed that this contamination was from an airborne source, probably the foam suppression equipment in and around the aeration lagoon. Despite the risk of limited vegetation effects off property, the Ministry believes that foam control has higher priority and must be continued.

Particulate Matter

Sampling for particulate matter indicated some improvement in 1982 over preceding years. There was a 10 percent decline in average dustfall (Table 8) although nearly half the monthly readings still exceeded the provincial objective. While wood fines continued to account for a substantial part of total dust-

fall near the mill, road dust and biological material (especially in the summer) also comprised a large fraction of dustfall. Most of the road dust was probably associated with mill operations. Snow sampling early in the year showed that saltcake was elevated only in the part of the buffer zone nearest the mill. However, carbon and suspended solids (tracers for wood fines) were above normal for up to 250 metres outside this zone.

Suspended particulate matter also decreased in 1982. The annual mean at the monitoring site near the mill (station 62030) was only 52 $\mu g/m^3$, well below the 1981 average of 74 $\mu g/m^3$ and within the Ontario limit of 60 $\mu g/m^3$. Only 7 daily values exceeded the 24-hour objective, compared with 19 in 1981. Wood fibres were sometimes noted on sample filters at this location. At the Fort Frances cemetery, the annual average was 32 $\mu g/m^3$, about normal for this site.

Odour Levels

Data from sulphation plates and continuous TRS monitors all indicated improved air quality in 1982. The decline in odour concentrations is clearly shown in the data summaries in Tables 9 and 10. Annual average sulphation, annual average TRS, and the number of TRS readings above the guideline all decreased from 1981 to 1982. Despite this improvement, there were still a large number of elevated readings (Figure 8). To obtain better coverage of air quality near the mill, the Ministry opened a new TRS monitoring station (62051, Figure 7) in August, 1982, near the La Verendrye Hospital. This instrument recorded the expected number and level of above-guideline readings during the part of the year it was in service. Our monitor at station 62030 also had to be moved in October to a new location (station 62052) nearby. Because the two sites are only 50 metres apart, there will be no loss in data continuity in this area.

Data from the sulphation plate at station 62047 and the TRS monitor at station 62032 show that the secondary treatment system

at the north side of the town is a significant source of offensive odours. TRS emissions from this sytem are, however, much lower than those from the mill.

Further odour controls at the mill, scheduled by September, 1983, are expected to continue the trend toward better air quality in Fort Frances.

KENORA

The Ministry has conducted air quality studies for the past 12 years near a sulphite pulp mill in Kenora. Occasional upset conditions in the plant have caused localized vegetation damage, and fallout of particulate matter emitted from the mill's power boiler stack has sometimes been a nuisance to nearby residents.

Vegetation Effects

Abnormal releases of sulphur dioxide from the mill on August 17 resulted in three complaints of vegetation damage. Gardens in a small area (less than 1 hectare) to the northeast of the mill sustained injury. The company altered the operation of its acid tower to prevent a recurrence of this discharge.

Particulate Matter

As Table 11 shows, average dustfall in Kenora in 1982 was the lowest recorded for several years. Dustfall exceeded the annual objective at only one of four sites (Figure 9) in the monitoring network. The decline in 1982 was attributed partly to below-normal production at the mill and partly to better control of power boiler emissions achieved in recent years. Although particles of flyash, lignite and bark char from the boiler stacks sometimes contributed to total dustfall at sites 61007 and 61009, episodes of significant fallout of this material in the nearby residential area now rarely occur. A snow sampling survey in March, 1982, confirmed that there was very little contaminant deposition off company property. None of the substances in fallout from the boiler stack is considered hazardous.

Sulphation Rates

Average sulphation rates decreased from 1981 to 1982 (Table 12). As noted for dustfall, this decline is related to the lower production levels at the mill last year.

MARATHON

Historically, the airborne contaminants of concern at Marathon have included mercury, particulate matter, and odorous compounds from a bleached kraft pulp mill and adjacent chlor-alkali plant. Mercury emissions ceased when the chlor-alkali plant was closed in 1977. Fallout of particulate matter in the townsite was shown in several surveys to be negligible.

Sulphation Rates

In 1982, to monitor general odour levels, the Ministry maintained five sulphation measurement stations in Marathon and one in Heron Bay (Figure 10). Table 13 shows that average sulphation levels have been fairly stable since mill modernization and pollution control programs were completed in 1978.

To determine if the mill fully complies with emission regulations for odorous gases, the Ministry installed a continuous TRS monitor in mid-December at station 63034.

Mercury in Surface Drainage Water and in Soil

To assess residual levels of mercury near the mill, soil samples were collected in the summer. Mercury in surface drainage water from four sites near the mill (Figure 11) was below detection limit; at site 1, it was slightly above. These findings confirm results from earlier surveys and show that negligible amounts of mercury are entering Lake Superior in surface drainage from soil around the mill.

Because of doubts about the validity of data from soil samples collected in July, 1982, the samples are being reanalyzed and the survey may be repeated in 1983.

RED ROCK

In Red Rock, the Ministry operates a small air quality monitoring network near a kraft pulp mill to measure dustfall levels and odour concentrations in the townsite. The network comprises four dustfall jars and sulphation plates at stations 63080 to 63083 and a continuous TRS analyser at station 63084 (Figure 12).

Dustfall

There was little change in average total dustfall, insoluble dustfall or percent saltcake in dustfall in 1982 compared to the two preceding years (Table 14). Two of the four sites met the annual dustfall objective. Saltcake, emitted from the mill's old recovery furnace stacks, accounted for 30 to 70 percent of total dustfall. Bark char, wood char and sawdust were commonly found in insoluble dustfall.

In compliance with a Ministry Control Order, a new recovery furnace and precipitator commenced operation at the mill in October, and the two old furnaces were shut down. This action is expected to substantially reduce saltcake fallout in the townsite. Dustfall data for early 1983 indicate that this objective is being achieved.

Odour Levels

Average sulphation rates (Table 15) declined slightly from 1981, but many values at stations 63080 and 63082 were at levels that indicated odour problems in the townsite. Our TRS monitor collected valid data for 292 days during the year. TRS concentrations exceeded the guideline for a total of 317 hours and the maximum hourly average, 339 ppb, was about 12 times the guide-

line. TRS at the highest level recorded might cause temporary discomfort to area residents. All high readings were associated with southeasterly wind, a direction which was recorded about 20 percent of the time in 1982.

With the mill's new recovery boiler in operation, sulphation rates and TRS concentrations should both decline sharply in 1983.

TERRACE BAY

Previous surveys have shown that the kraft pulp mill in Terrace Bay does not cause fallout of particulate matter in the adjoining townsite. Therefore, the Ministry's current monitoring program is directed toward measurement of odour levels in the townsite and at three points where an effluent ditch from the mill crosses the TransCanada Highway (Figure 13).

Odour Levels

While the highest average sulphation rate in 1982 was recorded at St. Martin School (Table 16), none of the readings indicated a significant odour problem. The first crossing point of the effluent ditch on the highway (station 63094) had the highest average sulphation rate, followed by progressively lower levels at the second and third crossing. Average sulphation at the third crossing was near normal background.

Because of instrument malfunction, valid TRS data were collected for only about 45 percent of the year. No monitoring was carried out from March to May, in August, or for most of September. Only seven readings above the TRS guideline were recorded, and the maximum hourly average was 50 ppb.

To alert the mill of pollutant concentrations above desirable levels, Kimberly-Clark has installed equipment to telemeter TRS data from St. Martin School to the mill. The current Control Order requires the company to comply with Ontario regulations for TRS emissions by June 30, 1984.

THUNDER BAY

The Ministry maintains a 10-station air quality monitoring network in Thunder Bay. Their locations, plus those operated by Ontario Hydro, are shown in Figure 14. In addition to a review of data from this network, the following discussion includes brief summaries of some special studies carried out in the Thunder Bay area in 1982.

Particulate Matter

Dustfall

Dust emitted from grain elevators has historically been a nuisance to Thunder Bay residents. Dustfall measurements near the elevators began in 1970, and the network has been revised periodically since then. The 1982 data for the 10 sites now monitored are summarized in Table 17. At four stations, the maximum acceptable limit for dustfall was never exceeded. Three sites (63005, 63021, and 63022) each had one exceedance. Station 63019 had four values above the monthly objective, mainly caused by a mixture of grain dust, road dust, and insect parts. The four elevated readings resulted in an annual average which was slightly above the Ontario objective at this site. The city-wide dustfall average was 3.6 $g/m^2/30$ days, well within the acceptable range and essentailly unchanged from the three preceding years. Now that the grain dust control program is complete, dustfall in Thunder Bay is expected to remain about at its present level.

There was a high frequency of elevated dustfall readings at station 63046 (Can-Car, Montreal Street) and station 63047 (Totem Trailer Court). The principal contributor to dustfall at both sites was flyash. It usually accounted for 80 to 90 percent of total dustfall at the Trailer Court, and a somewhat lower fraction at Can-Car. Emissions from coal-fired power boilers at Great Lakes Forest Products Limited are considered to be the source of this flyash fallout. Table 18 clearly shows the sharp rise in dustfall at the Trailer Court when regular use of coal began at Great Lakes in November, 1981. Several complaints of

flyash fallout were received during 1982 from residents around the Great Lakes mill. To reduce flyash emissions, the company is installing dust collection equipment which it expects to have in operation by September, 1983.

Suspended Particulate Matter and Soiling Index

Total suspended particulate matter (TSP) was generally recorded at satisfactory levels throughout Thunder Bay in 1982 (Table 19). Only 3 percent of the total samples for all six monitoring sites were slightly above the 24-hour air quality objective of 120 $\mu g/m^3$. TSP also met the annual objective at all locations. As shown by the graph in Figure 15, the multi-million dollar grain elevator dust control program has yielded significant benefits in improved air quality. Filters from the two city centre stations (63005 and 63022) showed acceptable concentrations of heavy metals, including lead, for which they are routinely analysed. Levels of sulphate and nitrate, due to long-range transport, varied considerably. Many filters exposed during the winter had a distinct "smoky" aroma, caused by emissions from residential wood-burning stoves. However, there was no relationship between the strength of the odour and total loading on the filter, nor between odour level and prevailing wind direction.

During the period of the year (January to July) for which data are currently available, soiling index levels were well within prescribed limits.

Gaseous Pollutants

Sulphur Dioxide (SO_2)

The principal industrial sources of sulphur dioxide in Thunder Bay are the 400-megawatt Ontario Hydro generating station and four pulp and paper mills. However, these sources are relatively small and total SO_2 emissions are less than 200 metric tons per day. The network of nine SO_2 monitors (seven belonging

to Ontario Hydro and two owned by the Ministry) showed full compliance for all SO_2 air quality objectives in 1982 (Table 20).

Total Reduced Sulphur (TRS)

At the Montreal Street monitoring site (station 63046), the TRS guideline was exceeded only seven times during the year, the lowest exceedance frequency since monitoring began in 1977 (Table 21). The maximum one-hour average and annual average were also the lowest yet recorded. The reason for this improvement is not entirely clear. Periodic production shutdowns at the Great Lakes Forest Products kraft mill, the principal source of TRS, may have contributed to this improvement.

Ozone (O_3)

Ozone did not exceed the maximum acceptable limit at any time in 1982 at the Ministry's monitoring site (station 63040). The highest one-hour average, 67 ppb, was very similar to the 1981 maximum. Highest readings were associated with southerly winds. Several studies have shown that ozone is a long-range transport pollutant whose primary source is large urban and industrial centres in the United States.

Special Studies

Pulp Mills

Vegetation surveys again showed that no visible injury occurred near the three sulphite pulp mills in Thunder Bay.

Thunder Bay Terminals Limited

A report on 1982 air quality near Thunder Bay Terminals Limited (8) showed that this coal terminal continued to operate satisfactorily. There has been no increase in dust levels at off-property monitoring sites since coal shipments began in 1978.

Thunder Tile Limited

For several years, emissions from this tile plant in Rosslyn Village, near Thunder Bay, resulted in elevated fluoride and minor injury to nearby vegetation (9). For economic reasons, Thunder Tile ceased production at the end of 1981. A Ministry report, now in preparation, shows that airborne fluoride and fluoride in vegetation fell to normal levels in 1982, and that there were no fluoride injury symptoms on sensitive plants.

Ontario Hydro - Thunder Bay Generating Station

A report is in preparation concerning a moss exposure study conducted during the spring of 1982 near Ontario Hydro's flyash disposal site. The data confirm results from the first survey in 1980 (10), which showed no off-property contamination by any of the elements examined.

ACKNOWLEDGEMENTS

The assistance of staff of the following agencies is gratefully acknowledged: Atmospheric Environment Service, Atikokan Weather Station, for operating a high-volume sampler; Dingwall Medical Clinic, Dryden, for assistance in operating our TRS monitor; Ministry of Industry and Tourism, Fort Frances, for help in operating the TRS monitors at stations 62030, 62051 and 62052; and Ontario Hydro for data from its SO_2 monitoring network in Thunder Bay.

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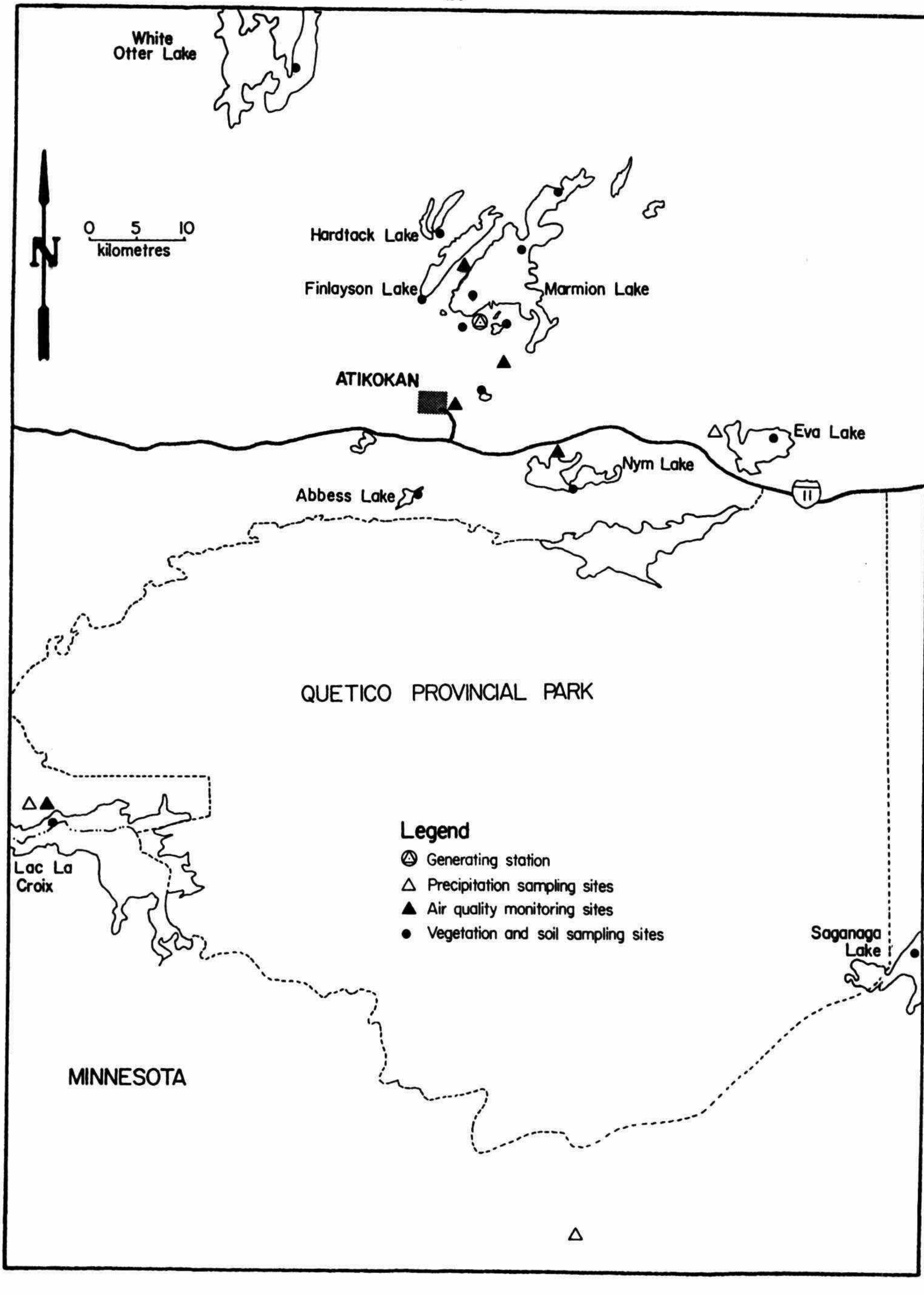

Figure I. Air quality assessment sites, Ontario Hydro generating station, Atikokan.

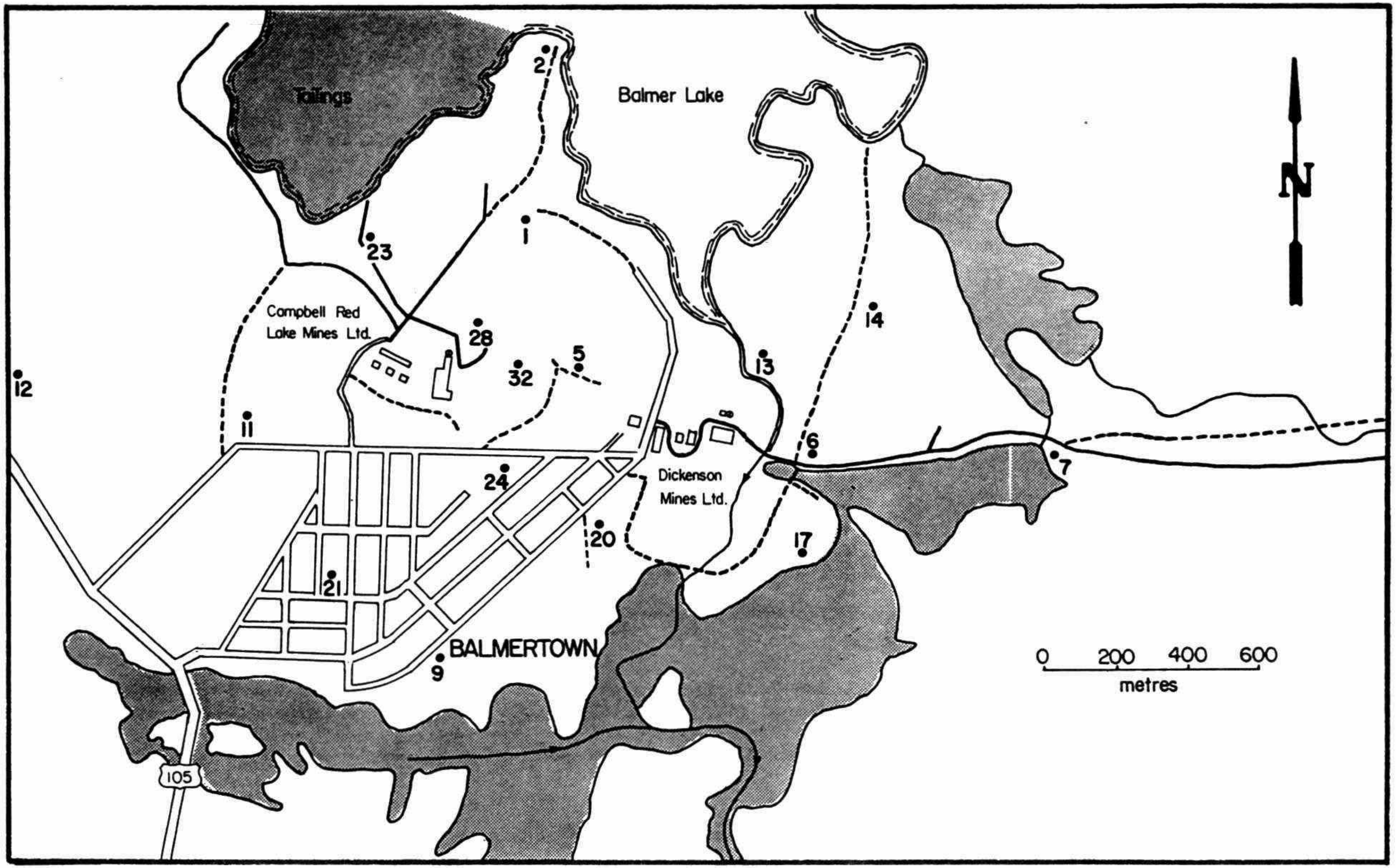

Figure 2. Trembling aspen sampling sites, Balmertown, 1982.

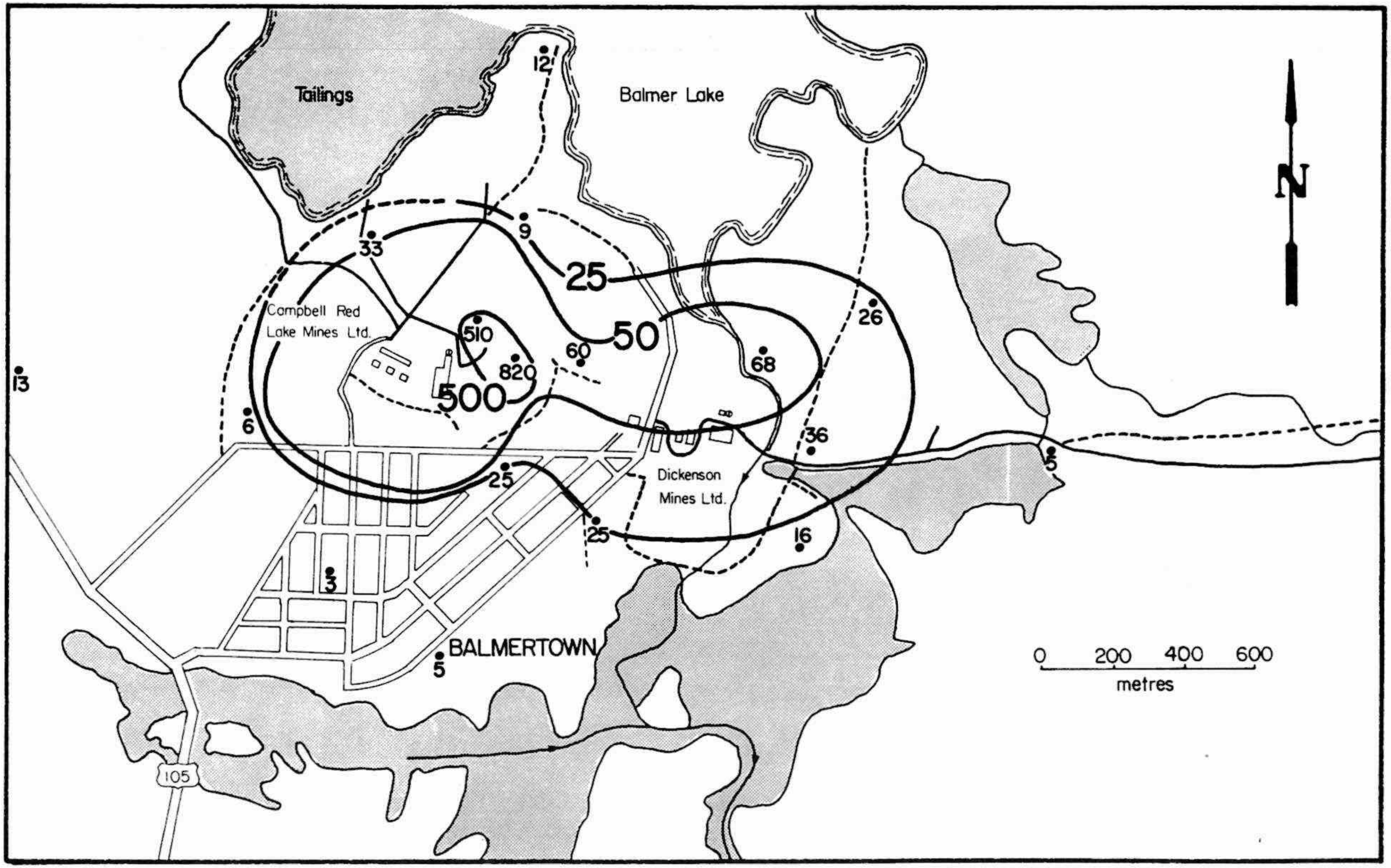

Figure 3. Arsenic levels (µg/g, dry weight) in trembling aspen leaves, Balmertown, August, 1982.

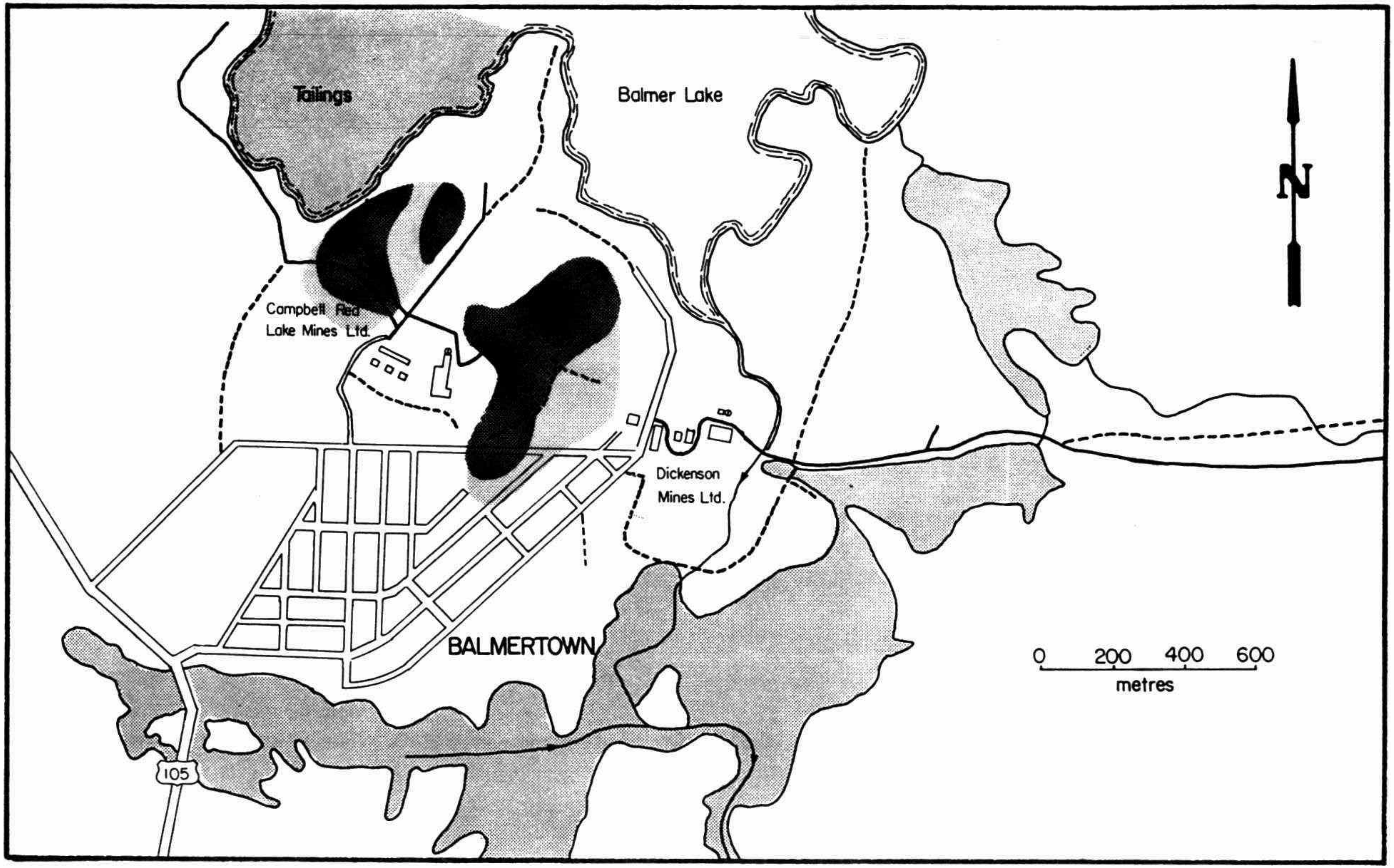

Figure 4. Sulphur dioxide injury to vegetation, Balmertown, August, 1982.

Moderate to severe injury

Trace to light injury

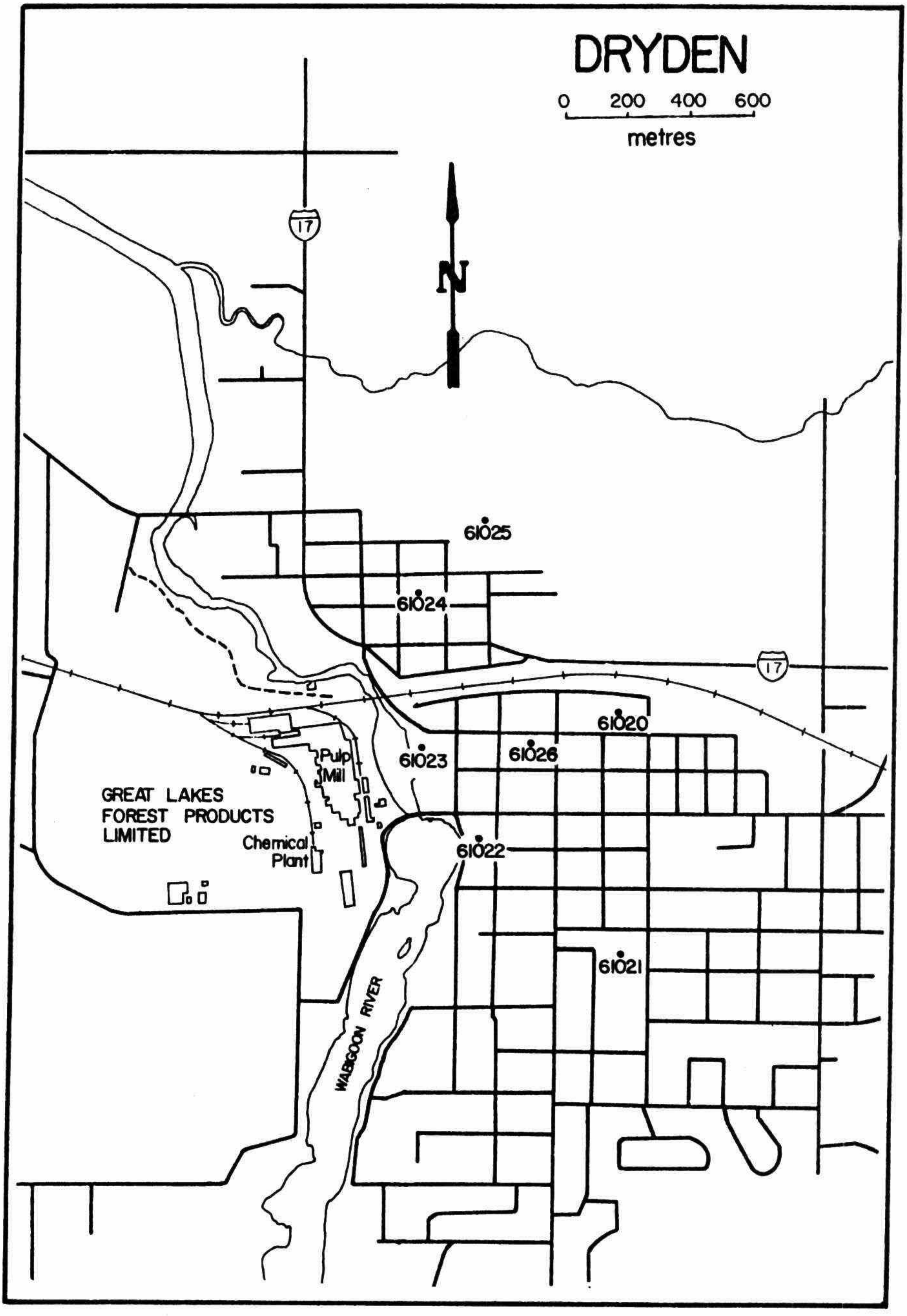

Figure 5 . Air quality monitoring sites, Dryden, 1982. (TRS only at 61026)

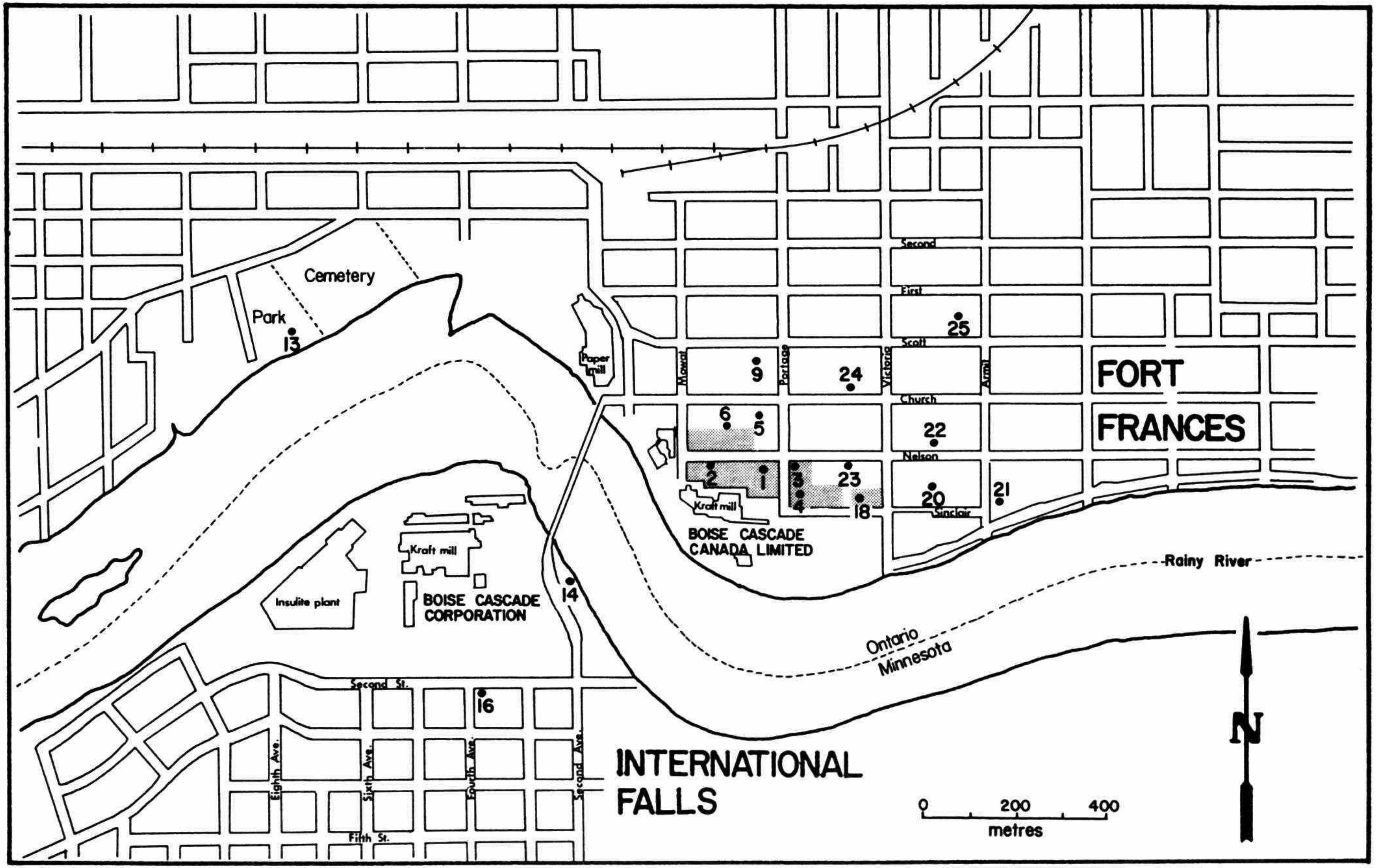

Figure 6. Manitoba maple sampling sites, Fort Frances, August, 1982.

Buffer zone

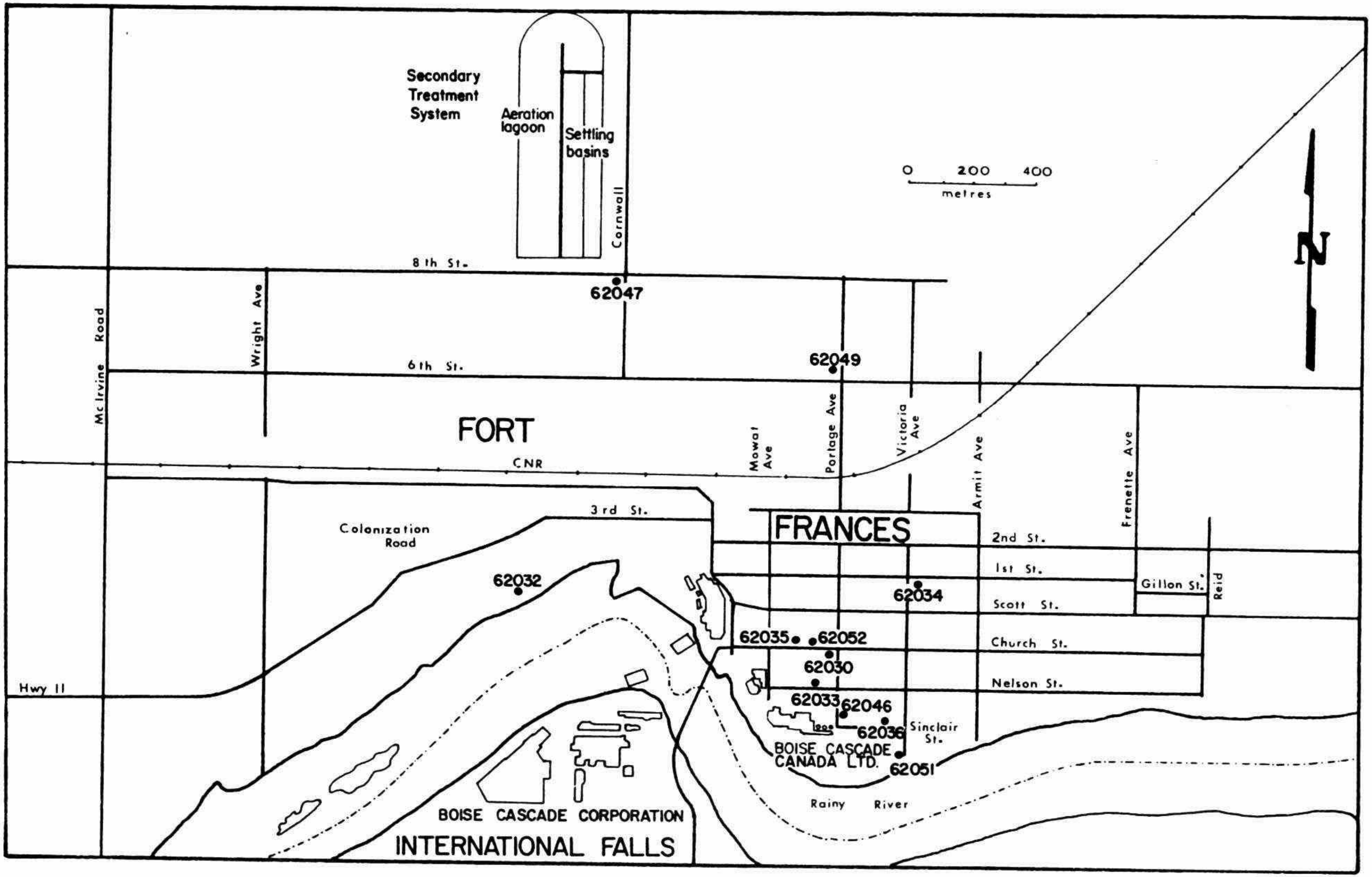

Figure 7. Air quality monitoring sites, Fort Frances, 1982.

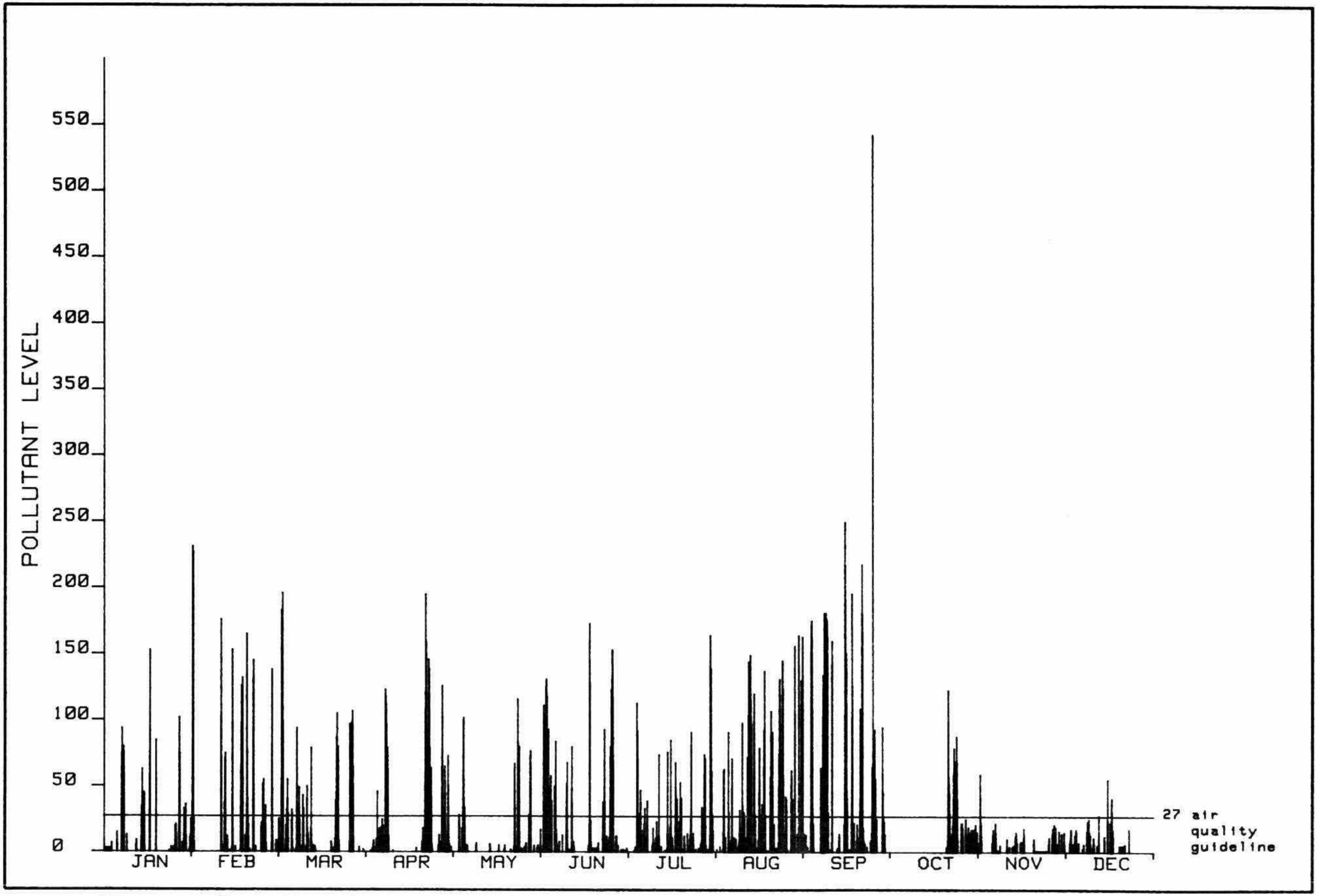

Figure 8 . Hourly average total reduced sulphur concentrations (parts per billion), station 62030, Fort Frances, 1982.

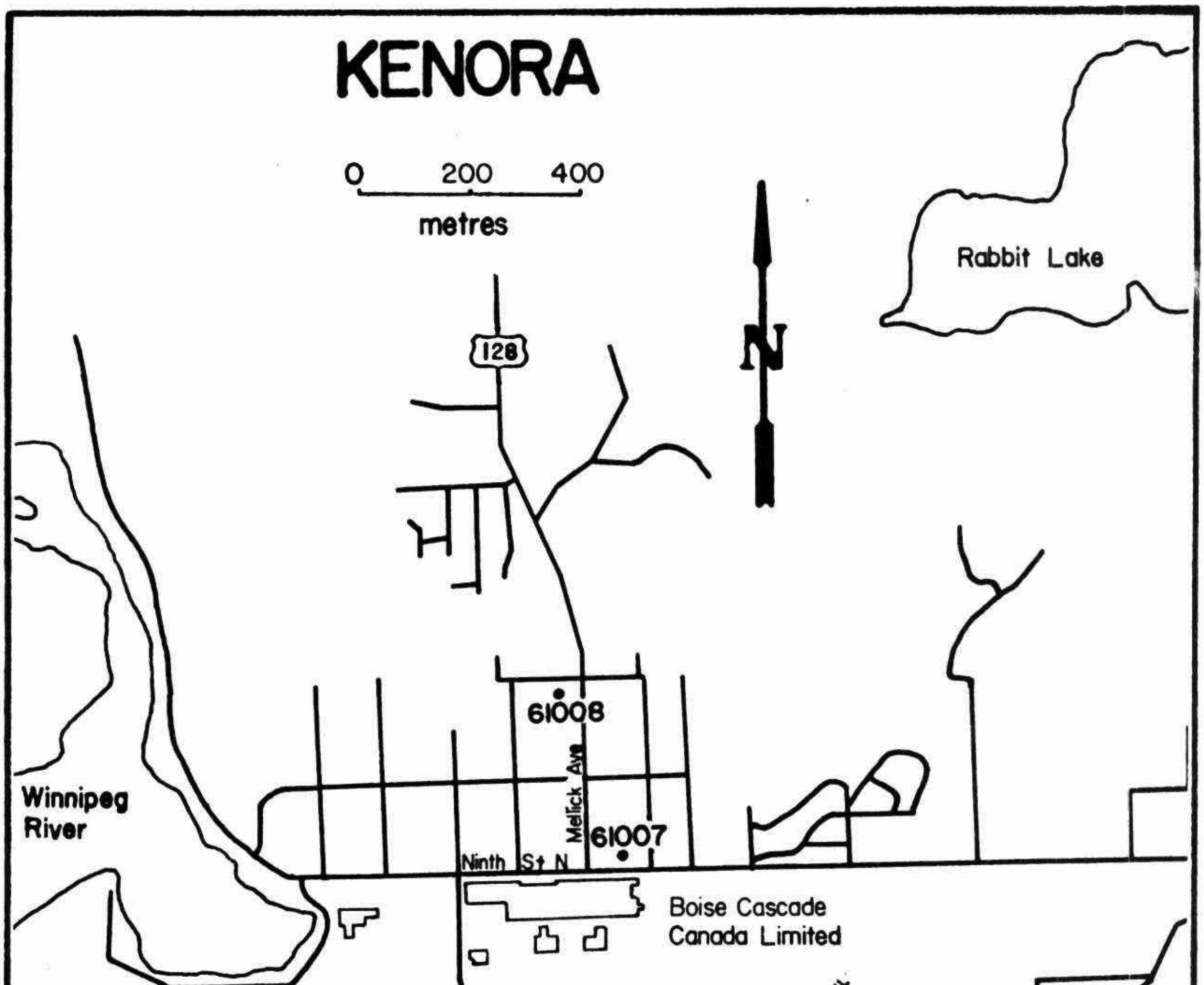

Figure 9. Air quality monitoring sites, Kenora, 1982.

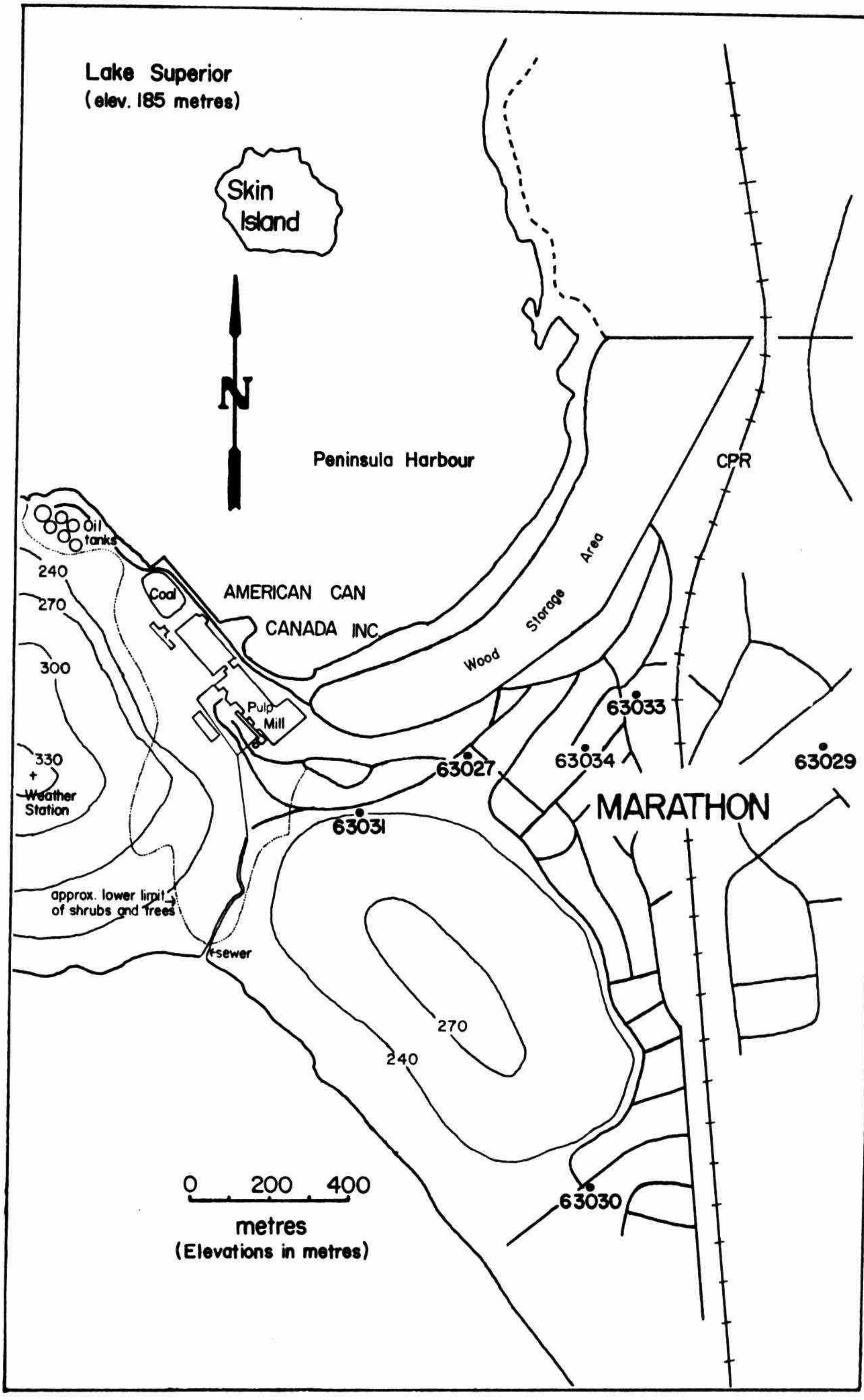

Figure 10. Air quality monitoring sites, Marathon, 1982 (except station 63032, Heron Bay).

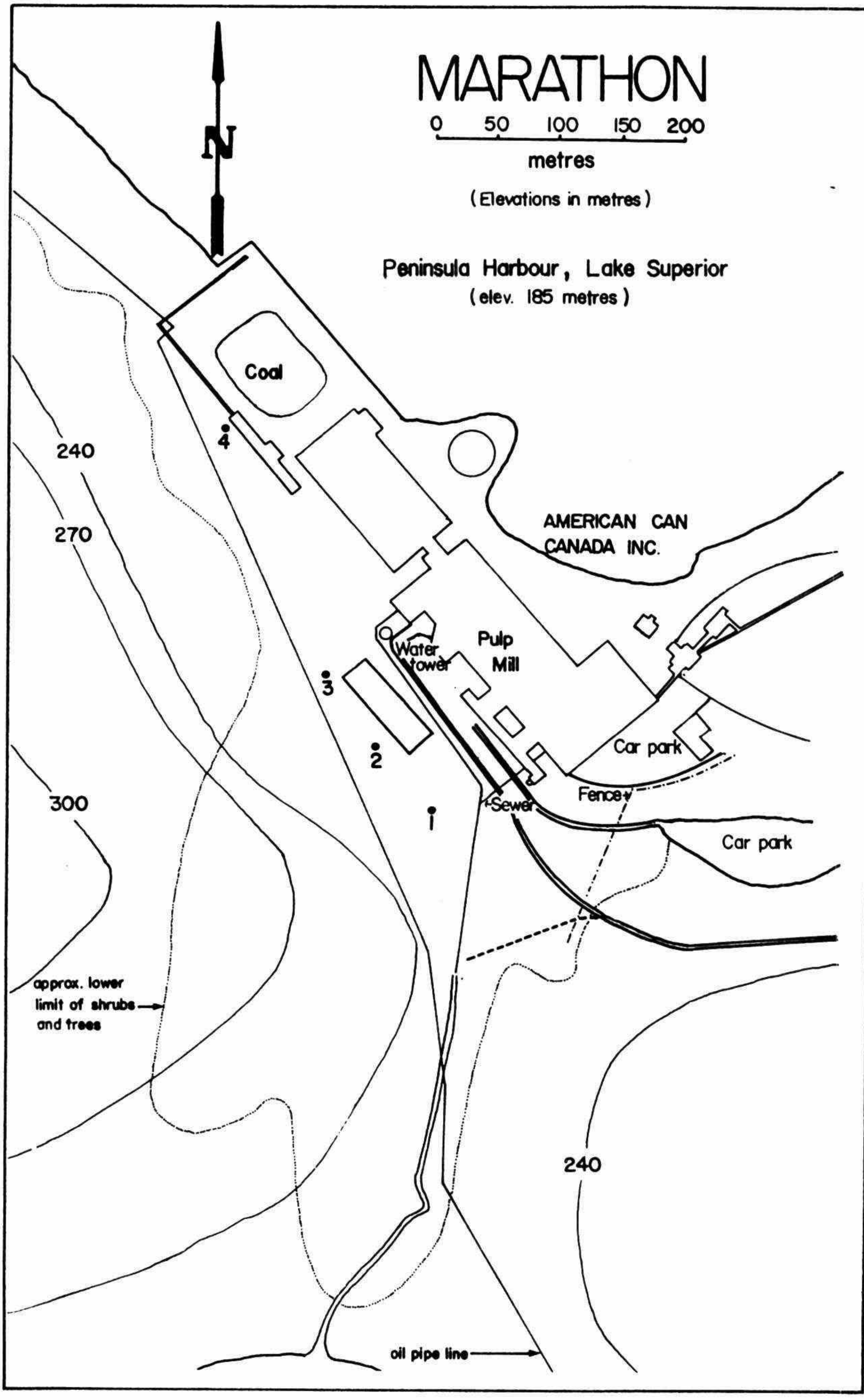

Figure 11. Surface drainage-water sampling sites, Marathon, 1982.

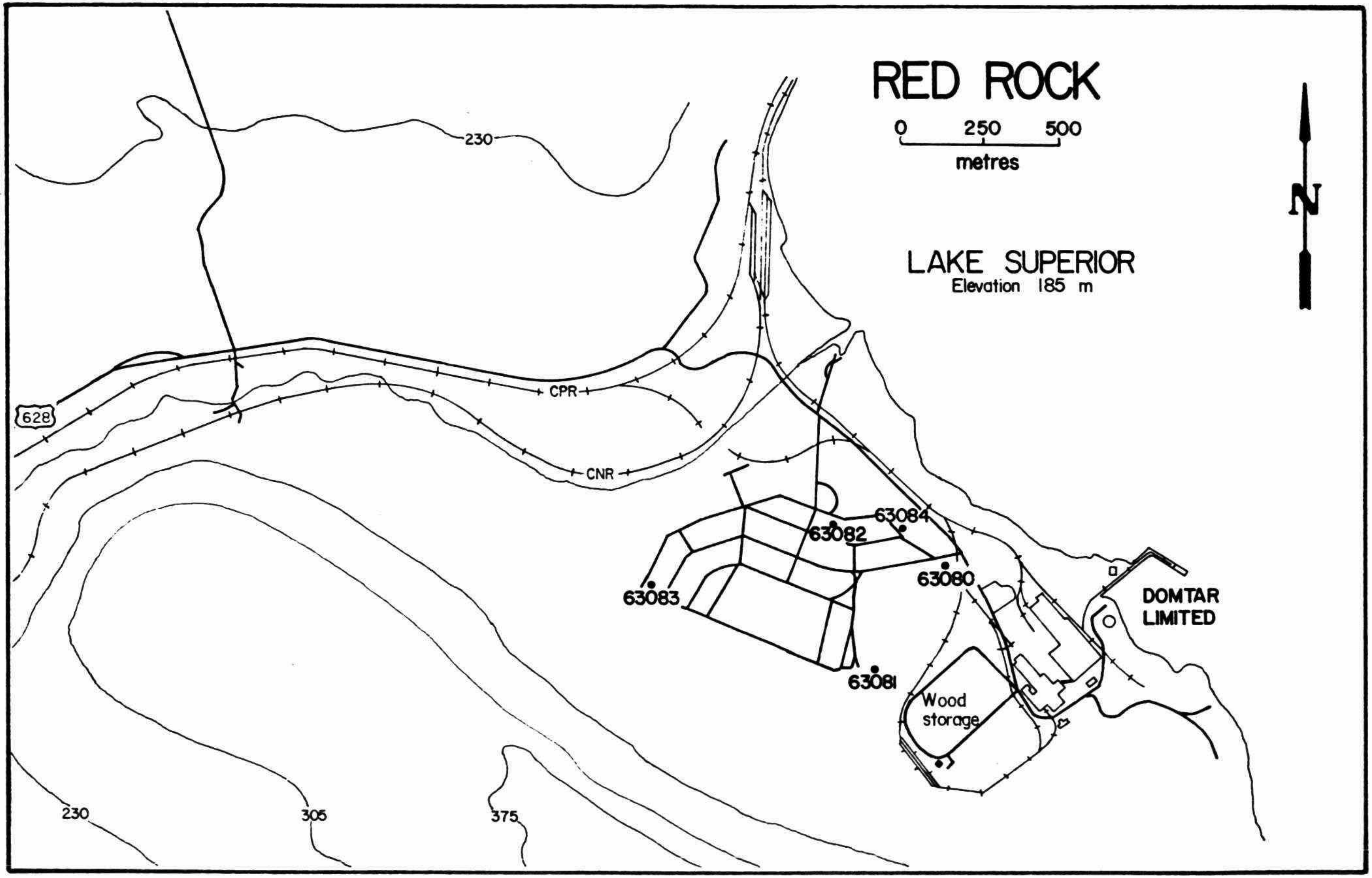

Figure 12. Air quality monitoring sites, Red Rock, 1982.

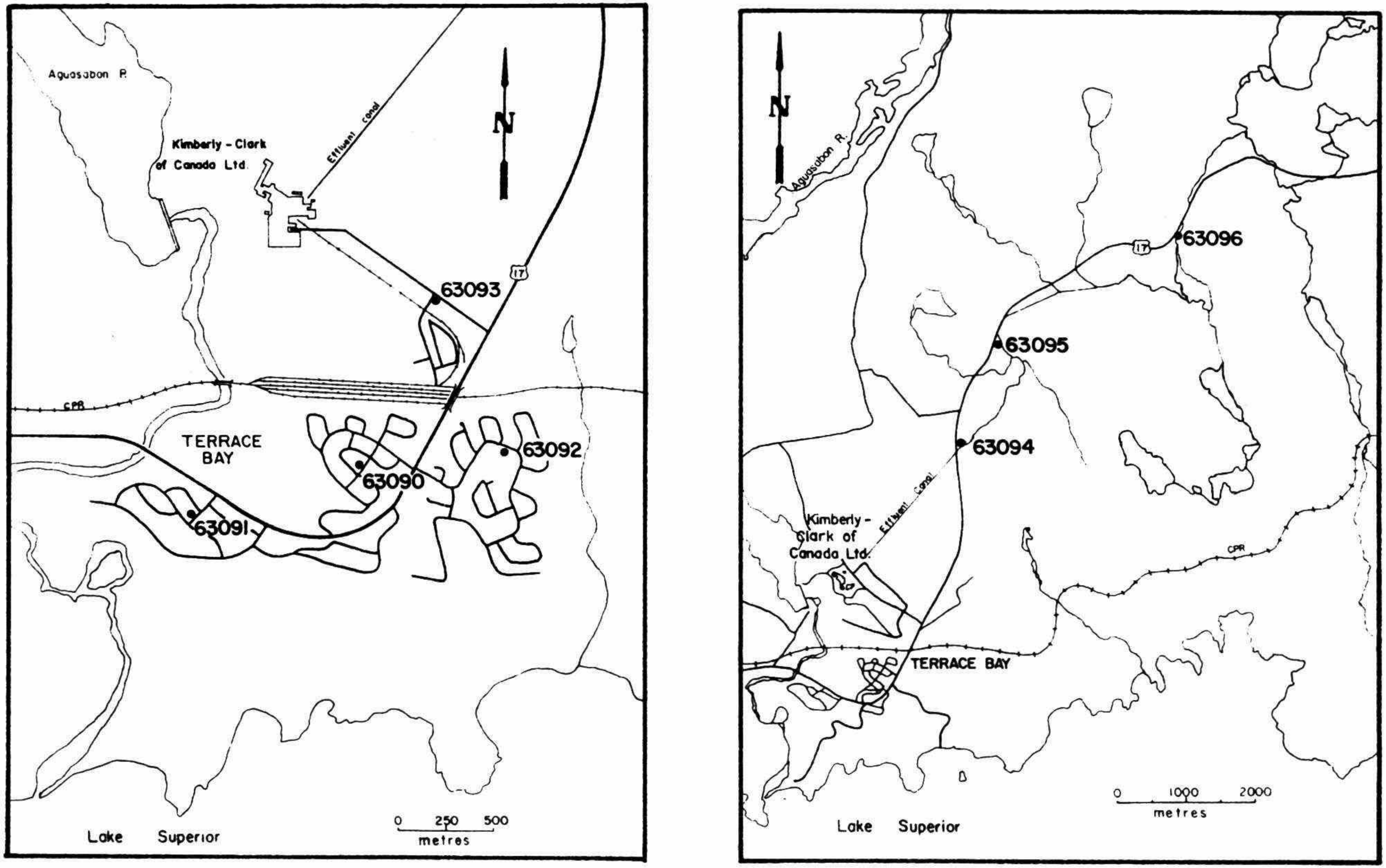

Figure 13. Air quality monitoring sites, Terrace Bay, 1982.

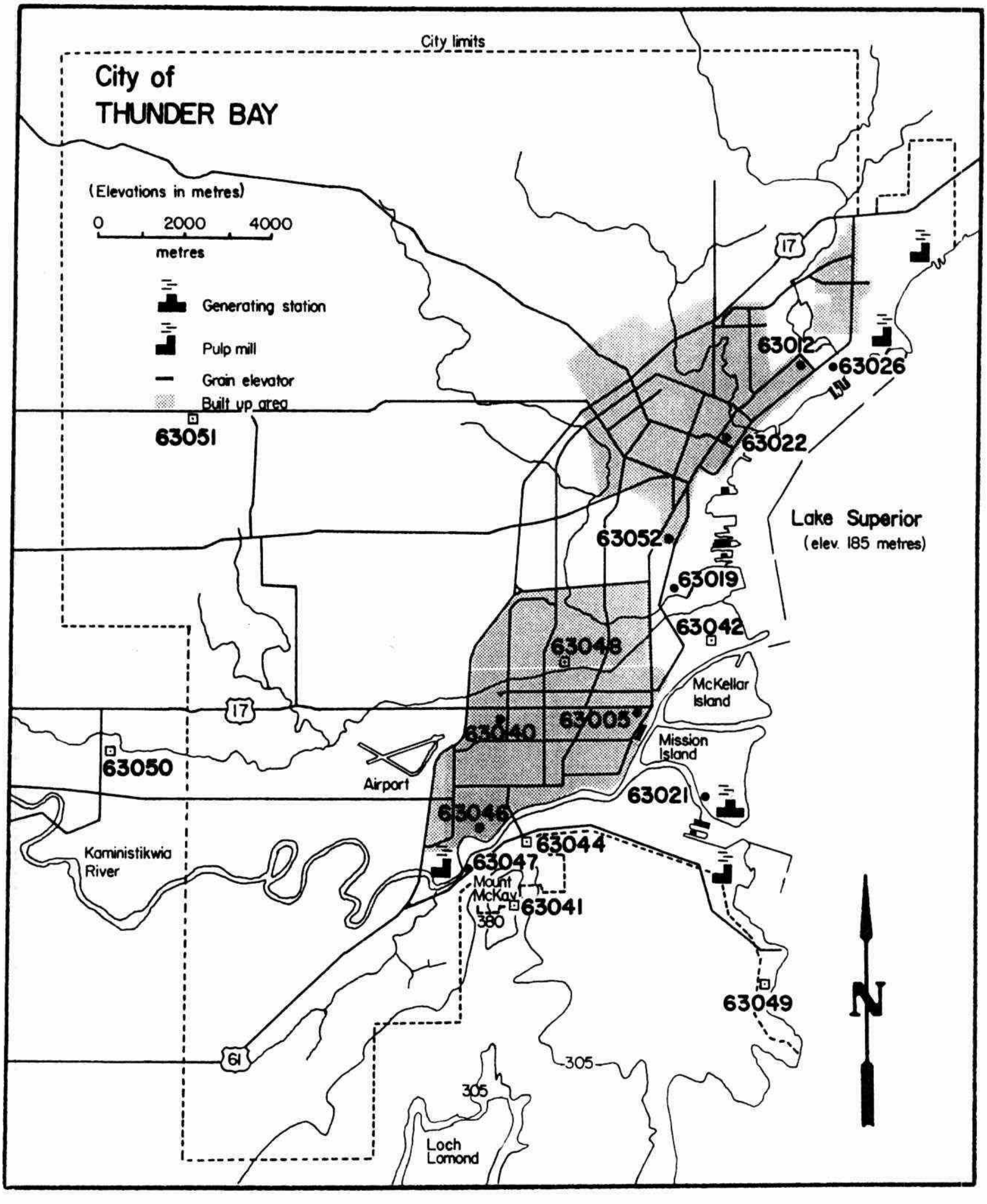

Figure 14. Air quality monitoring sites, Thunder Bay, 1982.
(▫ Ontario Hydro sites)

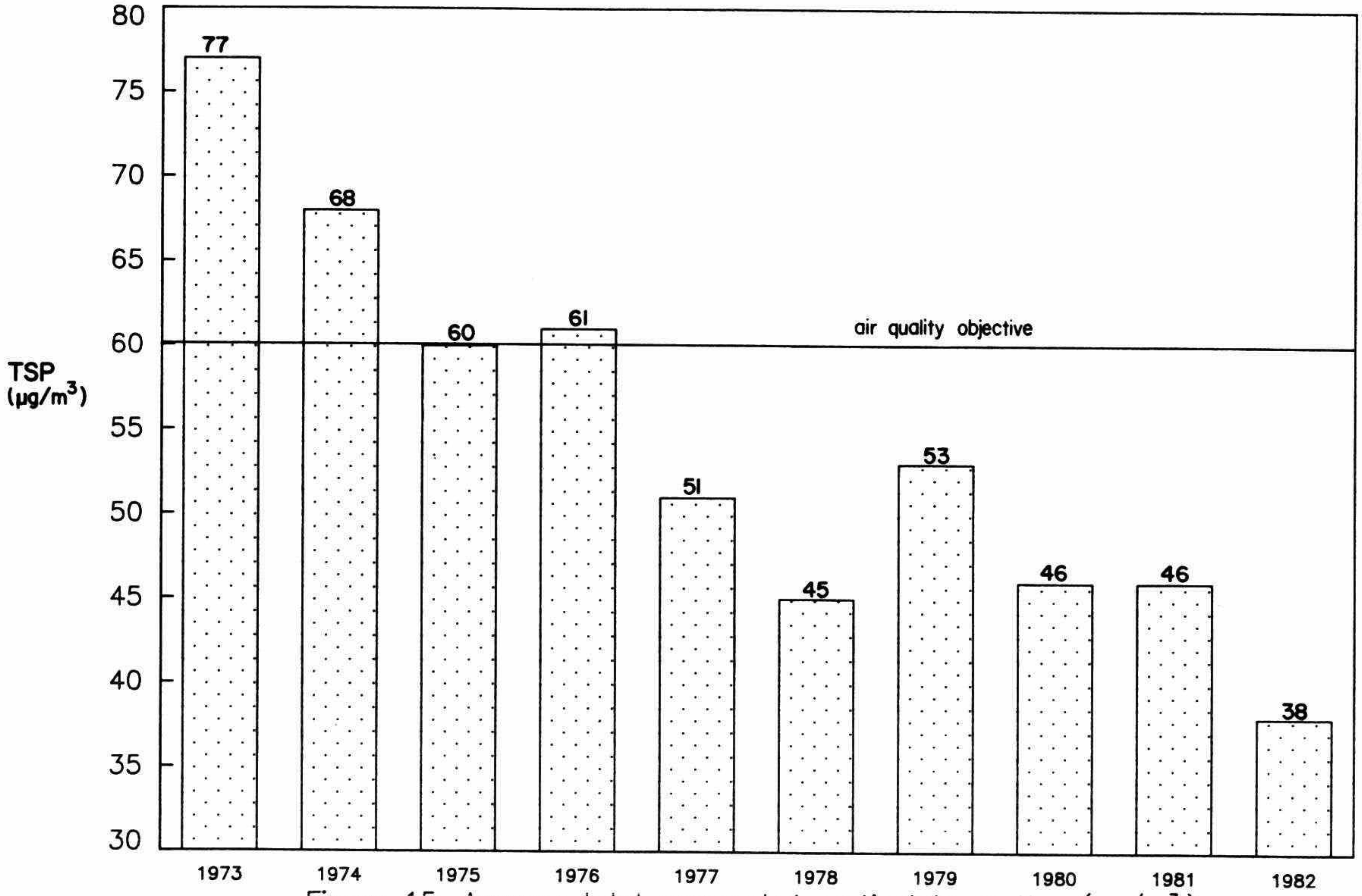

Figure 15. Average total suspended particulate matter (μg/m³), 1973–1982, Thunder Bay.

TABLE 1. Arsenic content (μg/g, dry weight) of unwashed trembling aspen foliage near Balmertown, 1972 to 1982.

Site[a]	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1			26[b]	31	10	5	4	3	6	5	9
2			22	26	6	12	9	3	6	4	12
5	160	550	29	33	18	12	9	22	28	6	60
6	78	400	200	260	50	8	33	11	55	63	36
7	21	81	43	29	5	4	20	4	4	2	5
8			14	18	4	2	6	2	2	1	
9	260	410	19	6	6	5	5	9	3	5	5
11	98	110	10	7	2	4	2	5	3	4	6
12	27	41	9	9	4	3	3	6	1	2	13
Controls	<1	8	3	2	<1	<1	<1	<1	<1	<1	<1

[a]Shown in Figure 2.

[b]Values above upper limit of normal background concentrations (5 μg/g) are underlined.

TABLE 2. Average arsenic content (µg/g, dry weight)[a] of unwashed foliage from planted roadside Manitoba maple (*Acer negundo*) and white elm (*Ulmus americana*) trees, Balmertown, 1973 to 1982.

Year	Side of tree[b]	Dickenson & Mine Road	Balmertown public school	Fifth St. & Mine Road	Controls
1973	Facing Away	504[c] 323	734 432	352 202	19 25
1974	Facing Away	70 31	36 21	20 12	4
1975	Facing Away	138 58	76 46	34 18	4
1976	Facing Away	18 18	12 9	20 11	2
1977	Facing Away	13 16	6 5	8 8	<1
1978	Facing Away	5 4	5 4	5 3	<1
1979	Facing Away	69 22		8 7	2
1980	Facing Away	7 5	5 5	6 3	1
1981	Facing Away	11 12	7 7	8 5	<1
1982	Facing	14	8	10	<1

[a]Values for 1975 to 1979 are averages of triplicate samples. Those for other years represent single samples.

[b]Facing and away from gold mines.

[c]Values above upper limit of normal background concentration (5 µg/g) are underlined.

TABLE 3. Average arsenic levels[a] (μg/g, dry weight) in washed vegetables and surface soil (0-5 cm) from three[b] Balmertown gardens, 1973-1982.

Sample	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
					Balmertown					
Potato leaves[c]		18	24	15	9	6	37	17	8	13
Potato tubers		2	2	2	<1	<1	<1	2	<1	<1
Beet leaves	180[d]	8	8	7	7	2	13	8	2	3
Beet roots	40	3	9	4	6	3	8	6	<1	5
Lettuce leaves	140	9	18	12	7	9	12	36	6	8
Garden soil		160	150	60	360	120	93	160	75	100
Lawn soil		570	450	210	340	280	270	440	320	310
					Red Lake (control)					
Potato leaves[c]		4	2	2	2	1	5	2	<1	2
Potato tubers		<1	<1	<1	<1	<1	<1	<1	<1	<1
Beet leaves	3	<1	<1	<1	<1	<1	1	2	<1	<1
Beet roots	2	<1	<1	<1	<1	<1	<1	<1	<1	<1
Lettuce leaves		2	<1	<1	<1	1	1	2	2	1
Garden soil		10	10	8	7	6	6	7	3	7
Lawn soil		14	10	9	8	11	24	11	7	13

[a]Values for 1975 to 1979 are averages of triplicate samples. Those for other years represent single samples.

[b]Two gardens in 1979.

[c]Unwashed.

[d]Values above upper limit of normal background levels (5 μg/g for vegetation, 20 μg/g for soil) are underlined.

TABLE 4. Average annual dustfall (g/m²/30 days), Dryden, 1976 to 1982.

Year	Station 61020	61021	61022	61023	61024	61025	All stations
1976	8.0[a]	6.3	9.8	11.5	5.9	4.5	7.7
1977	5.8	7.7	7.4	8.5	6.0	3.2	6.4
1978	4.7	5.1	6.0	4.6	2.9	2.5	4.3
1979	3.9	4.7	3.2	5.3	2.8	2.7	3.8
1980	3.2	3.8	4.6	5.2	3.8	3.9	4.1
1981	4.0	4.3	4.1	5.6	3.9	4.4	4.4
1982	3.8	4.4	4.8	5.4	3.8	4.2	4.4

[a]Values exceeding maximum acceptable limit of 4.6 g/m²/30 days are underlined.

TABLE 5. Average annual sulphation rates (mg SO_3/100 cm²/day), Dryden, 1976 to 1982.

Station	Location	1976	1977	1978	1979	1980	1981	1982
61021	Casimir/St. Charles		0.16	0.20	0.14	0.16	0.09	0.06
61023	King/Wabigoon	0.39	0.34	0.43	0.44	0.35	0.18	0.11
61025	Park/Second		0.13	0.12	0.14	0.12	0.10	0.05
61026	56 King Street			0.20	0.23	0.18	0.14	0.07

TABLE 6. Summary of concentrations (ppb) of total reduced sulphur, Dryden, 1977-1982.

Year	Days of data	Annual average	Maximum 1-hour average	Number of hours above guideline
1977	325	3.7	164	270
1978	282	6.7	479	400
1979	200	8.7	236	391
1980	275	6.1	436	476
1981	279	5.5	190	405
1982	312	2.1	139	153

TABLE 7. Average chloride and sodium concentrations in unwashed Manitoba maple foliage, Fort Frances-International Falls, 1980-1982.

Site[a]	Chloride (%, dry weight) 1980	Chloride (%, dry weight) 1981	Chloride (%, dry weight) 1982	Sodium (μg/g, dry weight) 1980	Sodium (μg/g, dry weight) 1981	Sodium (μg/g, dry weight) 1982
1	1.17	0.62	0.26	1800[b]	2090	560
2	0.81	0.43	0.30	1400	2200	1900
3	0.87	0.40	0.21	1200	710	120
4	0.71	0.22	0.21	620	330	190
5	0.35	0.22	0.13	260	330	160
6	0.36	0.38	0.21	390	800	770
9	0.22	0.18	0.22	150	130	86
13	0.04	0.04	0.03	83	72	110
14	0.08	0.08	0.13	53	126	230
16	0.53	0.16	0.41	73	69	88
18	0.21	0.11	0.10	120	60	38
20	0.10	0.09	0.08	250	140	120
21	0.15	0.11	0.14	250	70	48
22	0.13	0.12	0.11	240	100	120
23	0.26	0.12	0.06	280	100	57
24	0.42	0.24	0.22	210	150	99
25	0.17	0.20	0.11	410	230	120
Controls	0.10	0.08	0.07	100	56	65

[a]See Figure 6 for station locations.

[b]Values above upper limit of normal background concentration (600 μg/g) for sodium in vegetation are underlined.

TABLE 8. Average annual dustfall (g/m²/30 days), Fort Frances, 1981-1982.

Station[a]	1981 Total	1981 Insoluble	1981 Saltcake	1982 Total	1982 Insoluble	1982 Saltcake
62030	7.9[b]	4.9	1.3	6.9	4.0	1.5
62032	3.4	2.2	0.2	4.4	2.3	0.6
62033	9.7	4.0	2.9	7.8	3.4	2.6
62034	8.0	5.2	0.7	5.5	3.6	1.2
62036	10.0	6.2	1.3	11.1	6.8	1.5
62037	4.3	2.6	0.4	4.4	1.6	0.5
62046	10.4	6.2	1.5	10.0	6.1	1.3
Averages	7.7	4.5	1.2	7.1	4.0	1.3
% of total dustfall		58	16		56	18

[a]See Figure 7 for station locations.

[b]Values exceeding annual objective of 4.6 g/m²/30 days are underlined.

TABLE 9. Average annual sulphation rates (mg SO_3/100 cm^2/day), Fort Frances, 1979-1982.

Station	Location	1979	1980	1981	1982
62030	Church/Portage	0.20	0.14	0.11	0.09
62032	Cemetery	0.13	0.09	0.05	0.06
62033	Nelson/Portage	0.40	0.27	0.24	0.20
62034	First/Victoria	0.13	0.09	0.05	0.05
62036	Sinclair/Victoria	0.13	0.09	0.06	0.06
62037	Reid/Gillon	0.09	0.09	0.05	<0.05
62046	Sinclair/Portage	0.23	0.12	0.11	0.10
	Averages	0.19	0.13	0.10	0.08

TABLE 10. Summary of total reduced sulphur concentrations (ppb), stations 62030 and 62032, Fort Frances, 1976-1982.

Year	Days of data	Annual average	Maximum 1-hour average	Number of hours above guideline
		Station 62030		
1976	309	12.8	458	916
1977	294	15.4	480	969
1978	304	16.1	540	1035
1979	344	10.2	353	911
1980	352	9.3	499	872
1981	277	12.0	279	806
1982	320	8.8	543	685
		Station 62032		
1976	139	2.5	116	91
1977	225	3.3	129	176
1978	281	2.5	134	141
1979	306	2.9	140	178
1980	307	3.3	124	210
1981	271	3.1	211	202
1982	269	2.1	99	115

TABLE 11. Average annual dustfall ($g/m^2/30$ days), Kenora, 1977-1982.

Station	Location	1977	1978	1979	1980	1981	1982
61003	Fourth/Main	5.7[a]	9.5	4.6	4.1	4.7	3.1
61007	Melick/Ninth	11.9	14.7	8.6	10.7	14.1	10.0
61008	Melick/Eleventh	3.7	5.3	3.8	3.7	4.1	2.7
61009	Third/Matheson				5.6	7.1	4.5

[a]Values exceeding maximum acceptable level of 4.6 are underlined.

TABLE 12. Average annual sulphation rates (mg $SO_3/100\ cm^2$/day), Kenora, 1977-1982.

Station	Location	1977	1978	1979	1980	1981	1982
61003	Fourth/Main	0.23	0.21	0.24	0.16	0.11	0.07
61007	Melick/Ninth	0.21	0.24	0.17	0.16	0.21	0.10
61008	Melick/Eleventh	0.21	0.23	0.18	0.13	0.18	0.15
61009	Third/Matheson				0.06	0.07	0.05
	Averages	0.22	0.23	0.20	0.13	0.14	0.09

TABLE 13. Average annual sulphation rates (mg $SO_3/100\ cm^2$/day), Marathon, 1976 to 1982.

Station[a]	1976	1977	1978	1979	1980	1981	1982
63027	0.22	0.27	0.37	0.15	0.12	0.10	0.18
63029	0.15	0.17	0.20	0.17	0.09	0.09	0.11
63030	0.18	0.23	0.23	0.15	0.11	0.11	0.11
63031	0.46	0.56	0.71	0.19	0.20	0.09	0.21
63032			0.10	0.10	0.06	0.07	0.08
63033				0.16	0.16	0.15	0.15

[a]See Figure 10 for station locations.

TABLE 14. Average annual dustfall ($g/m^2/30$ days), Red Rock, 1980-1982.

Station[a]	1980			1981			1982		
	Total	Insoluble	Saltcake	Total	Insoluble	Saltcake	Total	Insoluble	Saltcake
63080	9.2[b]	4.0	2.6	8.6	3.3	2.7	9.8	5.0	2.8
63081	7.4	3.4	1.8	5.3	2.4	1.4	4.0	1.8	1.2
63082	12.5	3.6	6.0	14.7	3.2	8.4	9.9	2.4	7.1
63083	3.8	1.5	1.2	3.1	1.3	0.8	2.6	1.2	0.9
Averages	8.2	3.1	2.9	7.9	2.6	3.3	7.9	2.6	3.0
% of total dustfall		38	35		33	42		33	38

[a]See Figure 12 for station locations.

[b]Values exceeding annual objective of 4.6 $g/m^2/30$ days are underlined.

TABLE 15. Average annual sulphation rates (mg SO_3/100 cm^2/day), Red Rock, 1979-1982.

Station	Location	1979	1980	1981	1982
63080	Rankin Street	0.58	0.66	0.46	0.50
63081	Stewart/Frost	0.13	0.15	0.15	0.11
63082	47 Timmins Street	0.24	0.27	0.27	0.21
63083	122 Brompton Road	0.09	0.13	0.11	0.08
	Averages	0.26	0.30	0.25	0.22

TABLE 16. Sulphation rates (mg/SO_3/100 cm^2/day), Terrace Bay, 1982.

Station	Location	Average sulphation rate
63090	St. Martin School	0.15
63091	Ft. Garry Road	0.10
63092	Terrace Heights Dr.	0.10
63093	Mill Road	0.10
63094	Highway 17, #1	0.10
63095	Highway 17, #2	0.08
63096	Highway 17, #3	0.04

TABLE 17. Total dustfall ($g/m^2/30$ days) and average pH of dustfall solutions, Thunder Bay, 1982.

Station	Location	Min	Max	Mean	pH[a]
63005	McKellar Hospital	1.3	8.4[b]	3.8	4.6
63012	Dawson Court	0.2	5.1	2.7	4.7
63019	Main St. Pumping Station	0.6	14.1	5.2	5.4
63021	Mission Island	0.1	14.2	3.4	5.0
63022	St. Joseph's Hospital	0.8	7.3	3.5	4.2
63026	N. Cumberland Hydro	0.6	5.4	3.1	5.0
63040	435 James St. South	0.6	6.9	3.4	4.7
63046	Montreal Street	5.2	10.6	6.9	7.1
63047	Totem Trailer Court	7.2	17.5	11.7	6.0
63052	Thunder Bay Transit	1.1	6.3	3.5	4.1

[a]No data for February at all stations, and for April and June at most stations.

[b]Values exceeding maximum acceptable levels of 7.0 (monthly) or 4.6 (annual average) are underlined.

TABLE 18. Total dustfall ($g/m^2/30$ days) at Totem Trailer Court (station 63047), during winter months from 1977 to 1983.

Year	Nov	Dec	Jan	Feb	Mar	Mean
1977-78	6.8	8.1[a]	6.4	3.1	4.3	5.7
1978-79	1.5	1.5	2.8	0.1	3.0	1.8
1979-80	6.7	1.8	2.7	4.8	5.2	4.2
1980-81	3.0	2.9	1.8	5.2	4.9	3.6
1981-82	10.1	12.7	8.7	9.8	12.6	10.8
1982-83	17.5	15.1	16.6	16.0	9.8	15.0

[a]Values exceeding maximum acceptable level of 7.0 are underlined.

TABLE 19. Total suspended particulate matter (μg/m³), Thunder Bay, 1982.

Station	Number of samples	Annual geometric mean	Number of samples above 120 μg/m³	Maximum 24-hour value
63005	58	39	1	143[a]
63012	58	28	1	134
63022	59	39	nil	107
63040	56	27	nil	102
63046	57	45	3	140
63052	59	48	6	175

[a]Values exceeding the maximum acceptable limit of 120 μg/m³ (24-hour average) or 60 μg/m³ (annual geometric mean) are underlined.

TABLE 20. Summary of sulphur dioxide concentrations (ppm) in Thunder Bay, 1982[a].

Station	Location	Annual average	Maximum 1-hour average	Maximum 24-hour average
63022	St. Joseph's Hospital	<0.001	0.09	0.01
63040	435 S. James Street	<0.001	0.18	0.02
63041[b]	Mt. McKay		data unavailable	
63042[b]	East End		0.16	0.02
63044[b]	James St./Kam River		0.11	0.02
63048[b]	Ford Street		0.12	0.01
63049[b]	Chippewa Park		0.09	0.03
63050[b]	Paipoonge		0.04	<0.01
63051[b]	John Street Landfill		0.13	<0.01

[a]12 months of data for stations 63022, 63040 and 63050, 11 months for 63049, 10 months for 63042 and 63044, 9 months for 63048, and 7 months for 63051.

[b]Ontario Hydro. 1982-83. Environmental Quality Compliance Reports, 1982. Central Thermal Services, Thermal Generating Division.

TABLE 21. Summary of total reduced sulphur concentrations (ppb), station 63046, Thunder Bay, 1977-1982.

Year	Days of data	Annual average	Maximum 1-hour average	Number of times above guideline
1977	298	1.5	56	17
1978	280	1.9	48	28
1979	218	2.6	58	26
1980	220	2.9	131	90
1981	340	2.8	72	74
1982	299	1.0	36	7